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WALNUT BLIGHT IN THE EASTERN UNITED STATES.

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IMPORTANCE OF THE DISEASE.

The growing of the Persian (English) walnut in the eastern half of the United States is receiving increasing attention and arousing the interest of many. Persian walnut trees, mainly seedlings, either isolated or in small groups or orchards, are by no means uncommon in the States east of Lake Michigan and the Wabash River below the latitude of New England. An indication of the number of such trees now growing in this part of the country was contained in an address by Prof. F. N. Fagan, of State College, Pa., delivered before the Northern Nut Growers' Association in 1915, in which the statement was made that as the result of a recent survey by that college the "location of some 1,500 or 2,000 bearing trees" had been ascertained in that State. While there has been no effort to make a similar survey in other Eastern States, so far as the writer is informed, his personal knowledge and that of associates in the Bureau of Plant Industry indicates practically the same proportion of Persian walnut trees in the States of New York, Delaware, New Jersey, and Maryland. Isolated trees are known in lower Connecticut, southern Michigan, Ohio, and Virginia. Several eastern nurseries are now spe-

NOTE.—This bulletin is intended particularly for all engaged in propagating Persian walnuts in those portions of the United States east of the Rocky Mountains. It is also of scientific interest to plant pathologists.

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cializing in the growing of young trees for general planting. These facts, together with the increasing volume of correspondence received by the Department of Agriculture relative to walnut diseases and the known occurrence of the walnut blight, or bacteriosis, in the eastern United States, make it desirable to publish at this time a résumé of the history of this disease and its present status in the section specified, to the end that difficulties and disappointments may be avoided.

Commercial walnut growing in the United States may be said to have had its origin on the Pacific coast. At present the principal production of Persian walnuts in this country is from a few counties in southern California, although within recent years there has been extensive planting in the San Joaquin Valley, the Sacramento Valley and adjacent valleys of northern California, and in the Willamette Valley of western Oregon. To a considerable extent this walnut is now being planted by amateurs and experimenters in other States, especially Arizona and New Mexico. As a result of this situation, systematic studies of the species and its varieties, its cultural requirements, diseases, and insect pests have largely been confined to the West, and except as analogies can be drawn there is little in agricultural literature that will be of assistance to a prospective grower in the eastern United States.

During the seasons of 1910, 1911, and 1914 specimens of diseased nuts were received by the Bureau of Plant Industry from points in Maryland, Louisiana, Pennsylvania, Virginia, and Delaware and determined by Mr. M. B. Waite, Pathologist in charge of the Office of Fruit-Disease Investigations, to be affected with the so-called walnut blight, or bacteriosis. During the summer of 1916 an effort was made by the writer to determine the extent of the occurrence and the seriousness of this trouble in the eastern United States, as it appeared to be the most serious disease with which the industry now has to contend in this part of the country. Blighted nuts were found at practically all points at which bearing walnut trees were examined, and reports from other sections indicate that the presence of this disease is more or less general in the entire eastern district.

HISTORY OF WALNUT BLIGHT.

In 1901 Pierce[1] reported a walnut disease due to a bacterium which had at that time become established in the seedling orchards of southern California. He stated that it was highly pathogenic on young nuts, leaves, and tender twigs and frequently caused serious

[1] Pierce, N. B. Walnut bacteriosis. *In* Bot. Gaz., v. 31, no. 4, p. 272–273. 1901.

loss of young nuts. His paper gives a number of the characteristics of the organism in pure culture, and his work has subsequently been corroborated by Clayton O. Smith, of the Whittier Station in California, and the writer, in the eastern United States. Pierce proposed the term "bacteriosis" as being a suggestive name for the disease, though by growers the malady is commonly known and spoken of as walnut blight, which may be considered its common name. The disease-producing organism is now known as *Bacterium juglandis* (Pierce) Erw. Smith.[1] Since the publication of Pierce's paper reports by other writers have appeared from time to time, the most valuable contribution being Bulletin No. 231 of the California Agricultural Experiment Station.[2] The work reported in this paper, which extended over a period of some years, largely confirmed Pierce's studies and greatly augmented the existing knowledge of the disease-producing organism and its relation to its host.

A brief quotation will serve to indicate the seriousness with which this disease is regarded on the Pacific coast and the gravity with which it should be considered by present and prospective growers elsewhere.

> This is by far the most important trouble affecting the walnut in California. So serious has been this disease that the loss of a large portion of the crop has in some cases been charged to this source, legislatures have made special appropriations for its investigation, and the growers have offered a large reward for a practical remedy.
>
> At the same time the losses directly attributable to blight have been extremely large. One significant fact in this connection is that while the walnut acreage in southern California has multiplied many times during the past decade (1902–1912), the total walnut crop has increased very little during this time.
>
> This loss or failure of the crop to increase has not been entirely attributable to blight, yet it has certainly been due to the disease much more than to any other one factor.[3]

Until a few years ago walnut bacteriosis had been definitely known to occur only on the Pacific coast and in New Zealand. In 1913 Waite[4] reported the disease as occurring in the Eastern States. He stated:

> The California walnut bacteriosis has turned up at various points in the East. The twig-blight form of this disease is also prevalent in various States. The walnut blight, or bacteriosis, is therefore to be figured with in planting the Persian walnut in the East. . . . It occurs in Texas and Louisiana, and I think we have it in or near Buffalo, N. Y., and in New Jersey, so if I were

[1] Smith, E. F. Bacteria in Relation to Plant Diseases, v. 1, p. 171. Washington, D. C. (Carnegie Inst., Washington, Pub. 27.)

[2] Smith, R. E., Smith, C. O., and Ramsey, H. J. Walnut culture in California. Walnut blight. Cal. Agr. Exp. Sta. Bul. 231, p. 113–398, 96 fig. 1912.

[3] Smith, R. E., Smith, C. O., and Ramsey, H. J. Op. cit.

[4] Waite, M. B. The diseases of nut trees. *In* Rept. Proc. 4th Ann. Meeting, Northern Nut Growers' Assoc., 1913, p. 56. 1914.

planting extensively I should expect that disease to be serious. That would be my forecast of the matter. The humidity and cloudy weather in the East ought to be more favorable to the disease than the climate of California.

There is no reason to suppose that blight will not appear wherever Persian walnuts are grown.

THE DISEASE IN THE EASTERN STATES.

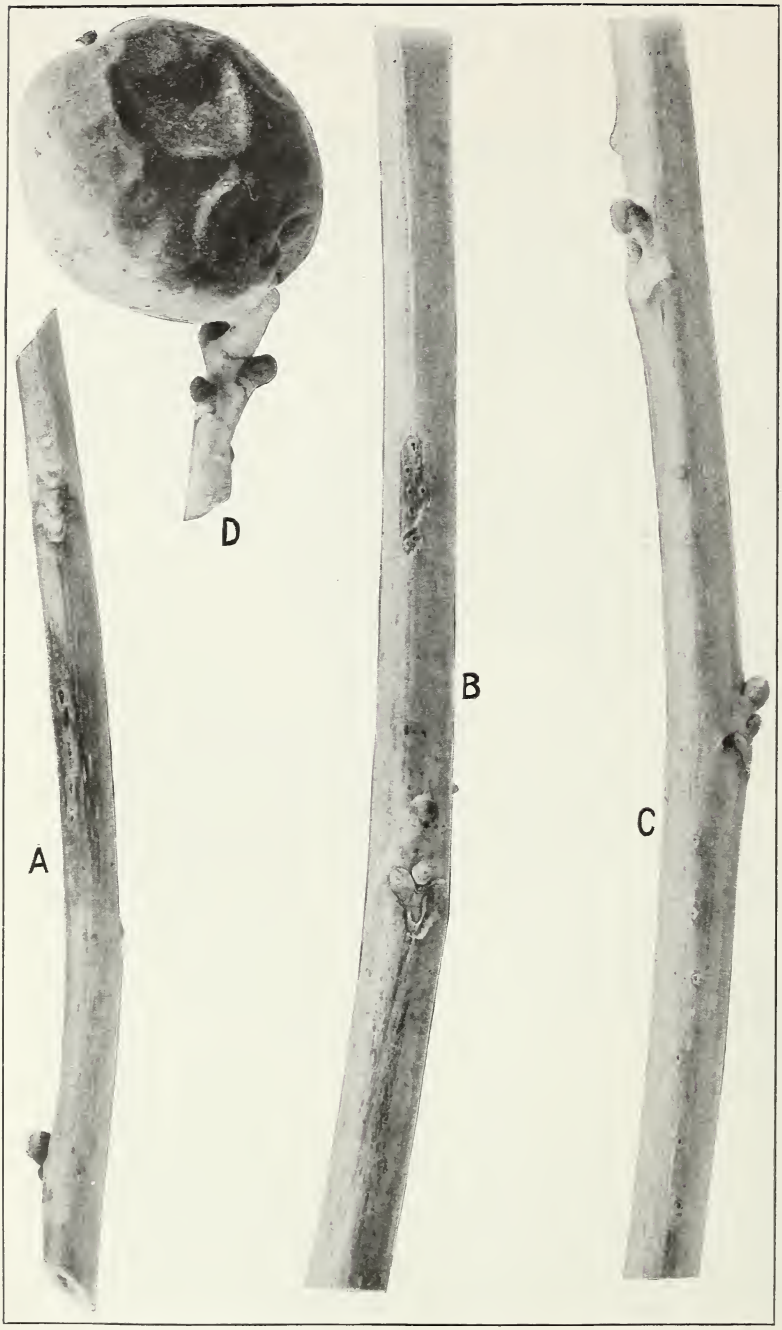
During the first week in June, 1916, a trip was made by the writer to various points in Delaware, New Jersey, and Pennsylvania where bearing walnut trees were known to be located. On practically every tree that had a crop the nuts were found to be spotted in a manner very characteristic of bacteriosis (Pl. I). The lesions at this time were small and superficial in character, rarely extending more than 2 to 3 millimeters (about one-tenth of an inch) into the husk. A number of specimens were collected and cultures obtained.

The technique used consisted in washing the nuts with soap and water, sterilizing the surface with an alcoholic solution of mercury bichlorid for five minutes, and then washing in distilled water. After this treatment the epidermis of the diseased spots was removed carefully with a sterile scalpel and bits of subepidermal tissue transferred to tubes of melted beef agar, agitated, further diluted in a second and third tube of the same media, and poured into Petri dishes. About 15 attempts were made, in practically all of which bacterial colonies of a similar type appeared on the plates in from two to four days, and the plates from the third dilutions usually contained colonies which were so few as to allow transfers to be made to tubes without difficulty. During the first week in August a series of inoculations was made on the nuts and twigs of a certain mature tree at Lancaster, Pa., which was said to be a seedling of Rush. The husks of 24 young nuts entirely free from any trace of the disease were inoculated (1) by spraying with a suspension of the germs in rain water, (2) by smearing on the culture, and (3) by puncturing with an infected needle. Several untreated nuts were tagged as controls. At the same time five young, tender, growing twigs 5 to 10 millimeters in diameter were inoculated with the germs about 6 inches from the tips by making several punctures in each with an infected needle; one twig was punctured with a sterile needle as a control. The organisms used in these experiments were all from pure cultures on beef agar and obtained as previously described.

A month later (Sept. 5, 1916) it was found that 21 of the 24 nuts inoculated had developed the disease and 3 showed no trace of it; the untreated nuts were perfectly clean. Of the five twigs inoculated, all had developed cankers from 5 to 10 mm. in length and from 2 to 5 mm. in width. Plate II shows one of the nuts 30 days after

BACTERIOSIS OF YOUNG PERSIAN WALNUTS.

The characteristic spots are caused by *Bacterium juglandis* (Pierce) Erwin F. Smith. Collected at Lancaster, Pa., June, 1916. (Natural size.)



DISEASED AND HEALTHY PERSIAN WALNUT TWIGS AND A NUT AFFECTED WITH WALNUT BLIGHT.

A and *B*, typical cankers produced on twigs in one month's time by needle punctures from pure culture; *C*, a control twig punctured with a sterile needle; *D*, a diseased nut one month after being inoculated from a pure culture by a needle puncture.

inoculation by needle puncture and two inoculated twigs having characteristic cankers. The control, which was punctured with a sterile needle, is shown at the right. The needle punctures in the control barely showed at this time, 30 days after inoculation.

Subsequently the organism was reisolated from a number of these inoculated nuts, and the cultural studies so far made from these isolations coincide with those made by Smith[1] and by Pierce.[2]

TIME OF INFECTION.

During the season of 1916 infection apparently took place about the last of May in the cases under observation. At this time the nuts were very well developed, approximately three-fourths to 1 inch in diameter, and although there was a slow increase in the area of the infection points through July and some coalescing of these spots to form larger ones, the disease did not begin to work deeply into the tissues until about the middle of August, by which time the shell had formed and hardened. By the end of the season the husks had become black, watery, and rotten, staining the shells and clinging to them when allowed to dry. The development of the nuts did not seem to be affected materially, if at all. The growers interviewed were unanimous in stating that infection was usually late and that no material shortage of crop resulted therefrom. However, the former part of this statement probably could be applied only to the time at which the infection became so evident as to attract the attention of ordinary observers.

In the California orchards the greatest loss from infection occurs at or near blooming time. Infection is serious in proportion as the weather is moist at that time. A dry, clear spring means little, if any, blight, whereas serious infection is associated with moist, foggy spring weather. The disease as observed in 1916 in Pennsylvania, Delaware, and the District of Columbia resembled closely the severe late infections described by Smith.[1]

CONTROL OF WALNUT BLIGHT.

Various attempts to control this disease by spraying and by soil applications have been made in California, and although some success has attended the spraying experiments it has not been of such degree as to extend any material encouragement to the commercial orchardist. That spraying will be of no value under eastern conditions can not be assumed from this fact, however, owing to the difference in the infection periods previously referred to. Nevertheless, spraying to control diseases of bacterial origin has never been

[1] Smith, R. E., Smith, C. O., and Ramsey, H. J. Op. cit. [2] Pierce, N. B. Op. cit.

so successful as in the control of those due to fungi; until the efficacy of spraying may have become established, too much should not be expected from this method of control.

A logical and seemingly practicable method of avoiding losses incident to bacteriosis is in the possible development of immune or highly resistant varieties. Work along this line is now under way on the Pacific coast, but it is not known that any varieties altogether resistant to blight or even practically immune to it have thus far been brought to light. However, among the many thousands of seedling trees on the Pacific coast and the hundreds in the eastern United States, it would not seem too much to presume that for general orchard planting blight-resistant and otherwise desirable varieties will yet be found. Whenever such varieties are discovered, arrangements may be made with the Department of Agriculture for testing their susceptibility to this disease by means of inoculation experiments. Meanwhile, it is to be hoped that the planting of small commercial orchards and of trees for home use will be continued, as small groups of bearing trees over a wide range of territory will furnish valuable suggestions as to future commercial plantings.

SUMMARY.

Walnut blight, or bacteriosis, is distributed very generally throughout the eastern half of the country. Investigations by Mr. M. B. Waite and the writer have demonstrated its occurrence in Louisiana, the District of Columbia, Maryland, Delaware, Pennsylvania, and New York, and there seems to be no reason to suppose that it will not occur wherever Persian walnuts are grown in the United States.

During the summer of 1916 pure cultures of the causal organism were obtained from naturally infected nuts; inoculation experiments were conducted in healthy nuts and twigs, and these inoculations were uniformly successful in producing the disease. Cultural studies were conducted in the laboratory, and the results obtained corresponded with those reported by Pierce[1] and by Smith.[2]

The writer's observations of this disease have covered one season only, and therefore definite conclusions as to its behavior under varying seasonal conditions are not possible. It may be stated, however, that late infections were the rule during the season of 1916, and if this condition holds generally true from season to season it will constitute a striking difference between the behavior of the disease in the Middle Atlantic States and on the Pacific coast.

Extensive experiments to control this disease by spraying have been conducted from time to time in California, but the results obtained have never been entirely satisfactory. Here, again, the differ-

[1] Pierce, N. B. Op. cit. [2] Smith, R. E., Smith, C. O., and Ramsey, H. J. Op. cit.

ence in infection periods may alter results, but from the best information at present available it appears that the solution of the problem of the control of this disease rests in the development of immune or highly resistant varieties. Nurserymen and growers should be on the watch for such sorts as combine a high resistance to this disease with the other qualities necessary in a good commercial nut, and whenever such varieties are found they should be propagated.

The wide planting of small lots of trees will furnish in the course of a few years valuable suggestions as to the requirements and range of the Persian walnut in the Eastern States, and should not be discouraged on account of blight. Although it is not possible at this time to say that this nut has large commercial possibilities in the section east of the Rocky Mountains, it is equally impossible to state the contrary as the fact. It is well established, however, that there are now hundreds of seedling trees in New York, Pennsylvania, New Jersey, Delaware, and Maryland bearing nuts of more or less merit despite the presence of this disease, and apparently there is no reason why every farm and country home in this district should not have a small planting of these productive as well as highly ornamental trees.

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